POSSIBLE CORRELATIONS CONCERNING POSITION OF SEEDS IN THE POD

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This study was made with the Henderson Lima bean on a block of ground one-fortieth of an acre. Nine rows of 10 hills each were planted 5 seeds to the hill in the manner shown in table I.

TABLE I

Row	Position of seeds in pod	Percentage of viability
1	2-seeded base	52
2	2-seeded tip	70
3	3-seeded base	60
4	3-seeded middle	76
5	3-seeded tip	56
6	4-seeded base	64
7	4-seeded first middle	60
8	4-seeded second middle	72
9	4-seeded tip	74
Total		584

Table I shows that seeds from the middle of 3-seeded pods had the highest viability, and that of those from the base of 2-seeded pods nearly one-half failed to produce plants. The average viability of the 3 rows planted with basal seeds was 58.6 per cent, the next lowest 66.6 per cent in the rows planted with tip seeds, and the highest viability 69.3 per cent, obtained in the rows planted with seeds from the middle of 3-seeded and 4-seeded pods.

Table II shows that the pods are chiefly of the 3-ovuled type, and that the others are somewhat equally divided between the 2-ovuled and 4-ovuled pods. The yield of pods from seeds of 2-ovuled pods is 15.61 per cent less than the average yield from seeds of 3-seeded and 4-seeded pods.

Pods from plants grown from seeds borne in the basal position numbered 1463, from seeds from middle position 1735, and in the

[1] This paper was received from the late Professor HALSTED in January 1918. A brief biographical sketch appears in the BOTANICAL GAZETTE of February 1919.

tip position 1403. This is 23.66 per cent more pods from the 3 rows planted with seeds from the middle of the pod than from the same area planted with seeds from the tip position, and

TABLE II

NUMBER AND TYPES OF PODS FOR EACH ROW, BOTH HARVESTS COMBINED

Row	Position of seeds in pod	2-ovuled	3-ovuled	4-ovuled	Total	Average per pod type
1.....	2-seeded base	44	343	17	404	.....
2.....	2-seeded tip	37	449	21	507	455.5
3.....	3-seeded base	55	487	36	578	.....
4.....	3-seeded middle	82	540	34	656	523.0
5.....	3-seeded tip	30	288	17	335	.....
6.....	4-seeded base	44	401	36	481	.....
7.....	4-seeded first middle	16	517	46	579	530.2
8.....	4-seeded second middle	47	388	65	500	.....
9.....	4-seeded tip	60	456	45	561	.....
	Total.....	415	3869	317	4601	.....

18.58 per cent more than the corresponding rows planted with basal seeds.

The percentage of each pod type in the crop for each pod type planted is given in table III.

TABLE III

Type planted	2-ovuled	3-ovuled	4-ovuled
2-seeded pods.....	8.88	86.95	4.17
3-seeded pods.....	9.09	84.87	5.54
4-seeded pods.....	9.48	81.11	9.41
Total.....	9.30	83.87	7.33

Table III shows but little variation in the number of 2-ovuled pods, but in 3-ovuled pods there is a decided decrease in the percentage, going from 2-seeded to 4-seeded, and, of course, a corresponding increase in the 4-ovuled pods, and where the percentages are low the differences are great, over 125.66 per cent between the crop from 2-seeded pods and that from 4-seeded pods. In other words, there is seen to be a tendency for seeds from 4-seeded pods to reproduce the mother type of pod. The number of pods for each

harvest and the percentages for the 3 types of pods are indicated in table IV.

TABLE IV

	Number of pods	Percentage of each type of pod		
		2-ovuled	3-ovuled	4-ovuled
First harvest.....	2672	7.11	84.73	8.16
Second harvest.....	1829	11.86	82.87	5.27
Total.....	4501	9.30	83.37	7.33

Table IV shows that the first harvest comprised nearly three-fifths of the total crop. It is further shown that the first harvest has its 2-ovuled pods below the average and its 3-ovuled and 4-ovuled pods above the average, while in the second harvest the reverse is seen. In other words, as the season advanced the average number of seeds in the pods increased.

TABLE V

Number and average weight of seeds

Row	Position of seeds in pod	Pods without aborts		Pods with aborts		Both averaged	
		Number	Average weight	Number	Average weight	Number	Average weight
1.....	2-seeded base	479	0.404 gr.	433	0.434 gr.	456	0.419 gr.
2.....	2-seeded tip	683	0.376	529	0.404	606	0.390
3.....	3-seeded base	881	0.376	539	0.411	710	0.394
4.....	3-seeded middle	912	0.396	662	0.424	787	0.410
5.....	3-seeded tip	413	0.390	371	0.419	392	0.405
6.....	4-seeded base	617	0.392	512	0.420	565	0.406
7.....	4-seeded first middle	799	0.391	630	0.422	715	0.407
8.....	4-seeded second mid.	878	0.385	783	0.415	831	0.400
9.....	4-seeded tip	803	0.360	528	0.387	666	0.378

Table V shows that the largest number of seeds (4624) was taken from the rows planted with seeds from the middle of the pods, while the number of seeds planted from the basal and tip seeds were 3461 and 3377 respectively. The average weight of all seeds from each row approximates the general average, the only striking deviation being in the lightness of the seeds grown from seeds produced in the tip position of 4-seeded pods.

Table VI shows under pod average (seed-weight for the 3 types of pods) that the heaviest seeds are produced in 3-seeded pods and the lightest are found in 4-seeded pods. It is also shown that the seeds in the basal position are lighter than elsewhere in the type of pod considered, and that in the combined harvests the seed weights

TABLE VI

RELATION OF POSITION OF HARVESTED SEEDS IN POD TO WEIGHT: I. SEEDS FROM PODS WITHOUT ABORTS AND AVERAGE FOR ALL 9 ROWS

	2-base	2-tip	3-base	3-middle	3-tip	4-base	4-first	4-second	4-tip	All
Both harvests	0.338	0.366	0.362	0.392	0.412	0.305	0.341	0.341	0.345	0.385
Pod averages	0.352			0.391			0.333			
First harvest	0.314	0.345	0.344	0.375	0.388	0.268	0.319	0.313	0.326	0.360
Pod average	0.329			0.369			0.307			
Second harvest	0.379	0.402	0.399	0.442	0.459	0.361	0.374	0.384	0.375	0.426
Pod average	0.390			0.434			0.374			

make a continuous rising series from the base to the tip for all types of pods. There is an exception in the records for separate harvests, but it is among 4-seeded pods, a type not largely represented, and small deviations are here to be expected. It is noted that the first harvest yields seeds of lighter weight than does the second harvest, and with a single exception (4-seeded base) the difference applies to each position in the pod.

TABLE VII

II. SEEDS FROM PODS WITH ABORTS AND AVERAGE FOR ALL 9 ROWS

	2-base	2-tip	3-base	3-middle	3-tip	4-base	4-first	4-second	4-tip	All
Both harvests	0.404	0.448	0.377	0.403	0.439	0.329	0.361	0.375	0.388	0.414
Pod averages	0.440			0.418			0.373			
First harvest	0.324	0.388	0.344	0.368	0.401	0.271	0.338	0.354	0.374	0.377
Second harvest	0.442	0.473	0.413	0.438	0.476	0.423	0.433	0.403	0.428	0.453

Table VII shows from the pod averages that the weight of the seeds decreases from 2-ovuled pods to 4-ovuled pods, and that the average weight of the seeds in 3-ovuled pods is very close to the average for all seeds. The averages for both harvests show that the lightest seeds are produced in the basal position, and that there is in all types of pods a uniform increase from the weights in the basal position to the weights in the tip position. In the first harvest the seeds in each position in each type of pod are lighter than the seeds for the same position in the second harvest.

A comparison of the weights of seeds for each pod position in the combined harvests of pods without aborts (table III) with those with aborts (table IV) shows that the former are uniformly lighter, as seen in the following statement:

	First harvest	Second harvest	Both harvests
Pods without aborts.....	0.360 gr.	0.426 gr.	0.385 gr.
Pods with aborts.....	0.377	0.453	0.414

The pod averages for seed-weights (tables III, IV) show that the seeds of 3-ovuled pods without aborts are heavier than are the seeds (average weights) in the other two types of pods, while among pods with aborts the average seed weight is greatest in 2-ovuled pods. This is shown in the following figures, in which both harvests are combined:

	2-ovuled	3-ovuled	4-ovuled
Pods without aborts.....	0.352 gr.	0.391 gr.	0.333 gr.
Pods with aborts.....	0.440	0.418	0.373

From these averages it is seen that the differences are considerable, and it may be assumed that it is due to local environment within the pod. For example, in a 2-ovuled pod the average weight of the seeds is 25 per cent more when one ovule aborts, 6.93 per cent in 3-ovuled pods, and 12.01 per cent in 4-ovuled pods. It is noted that the differences are greatest in the extreme or, as they may be called, exceptional pods. The influence upon the remaining seeds when two or more ovules abort in the larger types of pods cannot be determined from the records.

Percentages of gains in weight of seeds associated with aborts over the weight of seeds from pods without aborts for each position in the pod are as follows:

	2-base	2-tip	3-base	3-middle	3-tip	4-base	4-first	4-second	4-tip	All
Pod averages	19.25	22.40	4.12	2.81	6.79	7.87	5.87	12.17	12.46	7.79
	20.96		4.57			9.59				

It is seen that the gain of weight of seeds for pods with aborts over corresponding seeds in pods without aborts is greatest in 2-ovuled pods and least in 3-ovuled pods. It is further shown that the weight is most augmented in the tip position in all types of pods, and least in the position next above the base in 3-ovuled and 4-ovuled pods.

TABLE VIII

PERCENTAGE OF ABORTIVENESS FOR EACH POSITION OF SEEDS IN POD

Position of seeds in pod	First harvest	Second harvest	Both
2-seeded base	17.05	26.7	21.81
2-seeded tip	17.30	24.9	21.10
3-seeded base	14.30	23.0	18.65
3-seeded middle	13.10	23.4	18.25
3-seeded tip	17.80	24.8	21.30
4-seeded base	20.0	23.0	21.50
4-seeded first middle	16.2	22.8	19.50
4-seeded second middle	16.0	22.8	19.40
4-seeded tip	17.6	27.1	22.35

Table VIII shows that the abortiveness for each of the 9 rows is less in the first than in the second harvest. When the two harvests are combined, the range is from 18.25 to 22.35 per cent. It is further deduced that the average for the middle seeds (19.05 per cent) is the lowest, while the tip seeds yielded the highest (21.58 per cent) average abortiveness. From the standpoint of percentage of good seeds per pod, the middle seeds are the best for good crop productions.

TABLE IX

PERCENTAGE OF ABORTIVENESS FOR EACH POD POSITION IN WHOLE CROP

	2-base	2-tip	3-base	3-middle	3-tip	4-base	4-first	4-second	4-tip	All
Both harvests	49.55	11.88	40.11	12.95	13.25	52.63	13.93	5.26	4.34	19.75
Pod averages	30.74		19.02			19.04				
First harvest	31.77	8.83	47.34	7.96	2.29	55.50	12.84	5.50	3.21	16.83
Pod averages	20.31		15.77			19.26				
Second harvest	62.99	14.17	51.28	13.74	4.48	46.66	16.99	4.76	6.66	24.12
Pod averages	38.58		23.17			18.57				

Table IX shows that when the two harvests are combined the abortiveness is chiefly in the lower portion of the pod and is very large in the basal position. In all types of pods there is a regular decrease in the number of aborts from the base to the tip, with the

greatest range in 4-ovuled pods. The averages are more nearly alike than averages for position in the pod and are not strictly comparable.

In the first harvest the aborts are nearly two-thirds the number of those in the second harvest, but their distribution among the 9 positions in the pods does not follow fully the rule given for the whole crop. This is shown in the pod averages, where in the first harvest the smallest average is with the 3-ovuled pods, while in the second crop the smallest average is with the 4-ovuled pods.

A greater abortiveness in the second crop may be ascribed to the advanced age of the plants or to the lack of proper insect visitation, but this latter circumstance may not be significant, as Lima beans are understood to be self-fertilized. It is possible, of course, that the cause may be related to the atmospheric conditions prevailing at the time the ovules were ready to set, and this suggests the importance of repeating the present test through a series of years.

TABLE X

AVERAGE WEIGHT OF SEEDS AND PERCENTAGE OF ABORTIVENESS FOR EACH POD POSITION

	2-base	2-tip	3-base	3-middle	3-tip	4-base	4-first	4-second	4-tip	All
Seed weight ..	0.338	0.366	0.362	0.392	0.412	0.303	0.341	0.341	0.345	0.385
Abortiveness.....	49.55	11.85	40.11	12.95	3.25	52.63	13.93	5.26	4.34	19.75
Seed weight ..	7.0	3.0	4.0	2.0	1.0	8.0	6.0	6.0	5.0	.....
Abortiveness.....	2.0	6.0	3.0	5.0	9.0	1.0	4.0	7.0	8.0	.....

The ranking figures make it easier to compare the relationship of the average weights and abortiveness among their respective units. Table X shows at once that the position yielding the heaviest seeds has the lowest percentage of abortiveness, and, contrariwise, the position with the lightest seeds has the largest number of aborts. It is evident that the type of pod has much influence upon the weight of the seed, and it is only proper that the comparison here made should be within the pod. With this consideration in mind it is seen that the order from base to tip with all the pods is reversed, that is, the base bears the lighter (or lightest) seeds and with more (or most) abortiveness.

On account of the influence of pod type upon seed-weight and abortiveness it follows that the relative seed-weight does not necessarily determine the amount of abortiveness. For example, 2-ovuled pods bear seeds at their tips that are of the same weight as those formed at the base of 3-seeded pods, but the relative abortiveness is 11:40.

Summary

1. The greatest viability in Henderson Lima beans is associated with the seeds that are borne in the middle of the pods.

2. Three-seeded pods make up more than four-fifths of the crop; 3-seeded and 4-seeded pods are more numerous in the second of the two field harvests of ripe pods.

3. Seeds from the middle of the pod produce a much larger number of pods than do seeds from the base or tip.

4. The heaviest seeds are produced in 3-seeded pods, and the lightest in 4-seeded pods.

5. The seed weights make a continuous rising series from the base to the tip for all types of pods.

6. The first harvest yields lighter seeds than does the second harvest in each pod position.

7. The seeds associated with aborts are heavier than are those in full pods in each type of pod, and each position in the pod.

8. The abortiveness is less in the first than in the second harvest, and is least in the rows grown from seeds from the middle of the pods.

9. Abortiveness is chiefly in the basal position and decreases regularly from the base to the tip of the pod.

10. The position of the pod that yields the greatest weight of seed is associated with the lowest percentage of abortiveness.